Fraunhofer IPM

FRAUNHOFER INSTITUTE FOR PHYSICAL MEASUREMENT TECHNIQUES IPM

PRESS RELEASE

Recyclable packaging made from monomaterial

An infrared sensor enables control of material application during plasma coating

Ultra-thin barrier layers on packaging effectively protect food and medicine from oxygen, moisture, and contaminants. The Film-Inspect sensor, developed at Fraunhofer IPM, measures the quality of these barriers during the coating process, enabling process control for the first time.

Today, packaging is primarily composed of a blend of materials consisting of different polymer layers. Although composite materials have an excellent barrier effect, they are difficult to recycle. Packaging made from monomaterials, such as pure plastics, can be recycled extremely well. In many cases, coatings can provide monomaterials with a barrier function that is just as reliable as that of composite materials. For single-type recycling, as required by the new European Packaging Waste Regulation (PPWR), the proportion of foreign material due to coating should be in the per mille range or lower. Plasma coating processes can achieve this by depositing nanometer-thin coatings, consisting of materials such as silicon or aluminum oxide, onto a polymer substrate. To reliably protect products, these superbarriers must be of flawless quality. In other words, the required layer thickness and continuous coverage must be consistently achieved across the entire surface.

100 percent quality control of nanometer-thin coatings, even on uneven surfaces

A team at Fraunhofer IPM has developed a method to measure the quality of coatings thinner than ten nanometers immediately after the coating process, while still on the production line. This patent-pending method uses the material-specific infrared reflection of the coating. There is a linear relationship between the reflected infrared signal and the layer thickness, allowing conclusions about the thickness to be drawn. The Film Inspect sensor uses this relationship to measure layer thickness in just 0.2 seconds with an accuracy in the single-digit nanometer range. The sensor's optical design allows measurements to be taken even on complex, three-dimensional surfaces. To reliably control the quality, one measurement at a single point on the surface is sufficient. Since plasma expands spatially, the entire sample will be coated homogeneously, provided the surface within the measuring range has the desired coating thickness.

Editorial notes
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Process control implemented in plasma coating system

The sensor was tested in a project partner's production line. Plasma Electronic GmbH coats injection-molded polypropylene containers. Fraunhofer IPM installed and integrated various Film-Inspect sensors into their plant's control system to monitor the process. If the measured layer thickness does not meet specifications, the coating process can be adjusted by changing parameters such as plasma power, process time, gas flow rates, or chamber pressure. Thus, Film-Inspect not only enables quality assurance but also reduces waste and prevents overcoating.

In addition to superbarriers for monomaterial packaging and films, scientists at Fraunhofer IPM are exploring other markets. "Ultra-thin barrier layers are used in medical and aerospace technology to ensure sterility, reduce friction, and prevent corrosion," says project manager Dr. Benedikt Hauer. "Film-Inspect can also provide valuable information about the thickness and chemical composition of the coating in these areas."

Further information

The research on the Film-Inspect sensor was funded as part of the RE-USE and DeWaste projects

The RE-USE project (recyclable functional packaging for the food and pharmaceutical industries using ultra-thin barrier layers) was funded as part of the Fraunhofer-Gesellschaft's PREPARE program. The project was completed in 2025.

The DeWaste project (digitally monitored plasma coatings for safe and sustainable food packaging) was funded by the Baden-Württemberg Ministry of Economic Affairs, Labor, and Tourism (innovation competition "Climate-neutral production using Industry 4.0 solutions"). The project was completed in 2025.

Sensor: Film-Inspect at ipm.fraunhofer.de/en
Technology: IR material analytics at ipm.fraunhofer.de/en

The Film-Inspect sensor is robust, cost-effective, and no bigger than a chocolate bar. It enables 100 percent quality assurance for plasma coatings, creating an important prerequisite for using recyclable monomaterials in the packaging industry.
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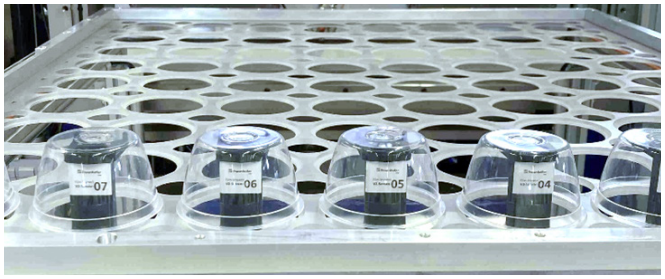

Eight Film-Inspect sensors examine the ultra-thin coating inside polypropylene cups and collect data for process control.
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